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Dietary intake of polyunsaturated fatty acids and fish among US children 12–60 months of age

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Abstract

This study aimed to estimate intake of individual polyunsaturated fatty acids (PUFAs), identify major dietary sources of PUFAs and estimate the proportion of individuals consuming fish among US children 12–60 months of age, by age and race and ethnicity.The study employed a cross-sectional design using US National Health and Nutrition Examination Survey data. Representative sample of US population based on selected counties. Subjects: 2496 US children aged 12–60 months. Mean daily intake of *n*-6 PUFAs and eicosapentaenoic acid (EPA) varied by age, with children 12–24 months of age having lower average intakes (mg or g day^{-1}) than children 49–60 months of age and the lowest n6 : n3 ratio, upon adjustment for energy intake. Docosahexaenoic acid (DHA) intake was low (20 mg day^{-1}) compared to typical infant intake and did not change with age. Compared to non-Hispanic white children, Mexican American children had higher DHA and arachidonic acid (AA) intake. In the previous 30 days, 53.7% of children ever consumed fish. Non-Hispanic black children were more likely than non-Hispanic white children to have consumed fish (64.0% vs. 53.0%). Results indicate low prevalence of fish intake and key n-3 PUFAs, relative to n-6 fatty acids, which suggests room for improvement in the diets of US children. More research is needed to determine how increasing dietary intakes of *n*-3 PUFAs like DHA could benefit child health.

Keywords

polyunsaturated fatty acids; children; fish; race

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Contributions SAK and AMB conceptualised and designed the research, interpreted the results, and reviewed and edited the final content. SAK drafted the manuscript. AMB analysed the data. All authors read and approved the final manuscript.

Introduction

Dietary polyunsaturated fatty acids (PUFAs) are necessary for maintenance of human health and are involved in a multitude of biological processes across organ systems, including cell membrane function, cell signalling, inflammation, and retinal and neural functioning (Neuringer *et al*. 1988; Uauy *et al*. 1990; Larque *et al*. 2002). The omega-3 (*n*-3) and omega-6 (*n*-6) PUFA families comprise numerous individual PUFAs with varying structure and function and are distinguished by the number of carbons and position and number of double bonds in the carbon chain. Linoleic acid (LA) and alpha-linolenic acid (ALA) are considered essential to basic functioning and are derived from the diet, while the major longer-chain fatty acids are both synthesised from the essential fatty acids and acquired directly from the diet. Intakes of several individual PUFAs of both the *n*-3 and *n*-6 families have been associated with clinically important health outcomes in children, with *n*-3 potentially benefitting neurodevelopment and behaviour and allergic disease, and *n*-6 potentially supporting growth in small infants but increasing risk for allergy (Carlson *et al*. 1992, 1993; Sinn & Bryan 2007; Makrides *et al*. 2010; Nwaru *et al*. 2012). For instance, docosahexaenoic acid (DHA, *n*-3) accumulates in large concentration in the developing brain, and accretion in the brain is highly active from late fetal development until at least age 2 (Kishimoto *et al*. 1969; Sun & Sun 1972; Martinez 1994). DHA supplementation has been shown in some clinical trials to promote the cognitive and visual development of children born preterm [mean advantage in Bayley-II mental development index, per meta-analysis = 3.44 (95% confidence interval: 0.57, 6.31); Makrides *et al*. 1995, 2000, 2010; Clandinin *et al*. 2005; Fang *et al*. 2005]. Dietary supplementation with eicosapentaenoic acid (EPA, *n*-3) has been shown to improve symptoms of attention deficit-hyperactivity disorder (ADHD) in school-age children (Sinn & Bryan 2007; Johnson *et al*. 2009). Arachidonic acid (AA, *n*-6) may be important for sustaining infant growth, although this has been an inconsistent finding (Carlson *et al*. 1992, 1993). In addition, the ratio of *n*-6 to *n*-3 PUFAs is sometimes used as an indicator of diet quality in that a low ratio suggests a healthier overall balance of PUFAs in the diet than a high ratio (although this is not a universally adopted measure) (Blasbalg *et al*. 2011; Aranceta & Pérez-Rodrigo 2012).

Dietary recommendations exist for only LA and ALA in the United States (adequate intake: LA: 7.0 g day^{-1} for 1–3 years, 10.0 g day^{-1} for 4–8 years of age;ALA: 0.7 g day^{-1} for 1–3 years, 0.9 g day^{-1} for 4–8 years of age), and recommendations for other PUFAs vary widely across other countries. One reason for the wide ranging nature of these recommendations is that optimal levels of overall and individual PUFA intake are unclear. In addition, there is little published data on dietary intakes of specific PUFAs in young children. National Health and Nutrition Examination Survey (NHANES) data from 1999 to 2000 indicate that the mean daily dietary DHA intake among US children between 0 and 6 years of age who are no longer nursing is approximately 20 mg day^{-1} (Ervin *et al*. 2004). Whether intake varies within this wide age range is important as the youngest children may have the greatest need for certain PUFAs in their diets because their overall physical as well as brain growth are at their most rapid pace. Also, because there exist substantial racial and ethnic disparities in the United States in paediatric health conditions that may be influenced by PUFA intake (e.g. ADHD, asthma), it is important to investigate potential dietary disparities that have not been previously examined in US children (U.S. Department of Health and Human Services, Health Resources and Services Administration, Maternal and Child Health Bureau 2009; Oraka *et al*. 2013).

No studies have identified the food sources that are the greatest contributors to PUFA intake among young children in the United States, which may differ from previously identified sources in adult diets (National Cancer Institute 2010a). Only a small number of foods contain high levels of certain *n*-3 PUFAs in a portion size appropriate for very young children. For instance, fatty fish like salmon, tuna and mackerel – among the food sources with the highest concentrations of EPA and DHA and common in the diets of adults – may not be often offered to young children because of concerns about potential food allergies or methylmercury reflected in complex clinical recommendations and public health messages (Fiocchi *et al*. 2006; U.S. Environmental Protection Agency and U.S. Food and Drug Administration 2004). As a result, it remains unclear which foods contribute most to PUFA intake among young children. Examining fish consumption alongside overall PUFA intake would help explain any differences observed in PUFA intake. To our knowledge, no studies have examined age and race and ethnicity differences in fish intake among young children in the United States.

To address these gaps in the literature, this study examined data from the 2003–2008 cycles of NHANES to identify the foods that are the greatest contributors to PUFA intake among children 12–60 months of age and the types of fish consumed. Daily dietary intake of PUFAs (*n*-3: ALA, EPA, DHA; *n*-6: LA, AA) was also estimated, by age and race and ethnicity to examine changes with age and also disparities.

Materials and methods

Study sample

For this analysis, data from the NHANES from 2003 through 2008 were used. Data were from children ages 12–60 months who participated in the mobile examination centre (MEC) component of NHANES and completed the first 24-h recall the MEC examination. Of the original 3215 age-eligible children who were examined in the MEC, 2885 (90%) had administered as part of complete first-day dietary recall and were therefore eligible for this analysis. The average response rate for the 2003–2004, 2005–2006 and 2007–2008 NHANES was 79% for the household interview and 76% for the MEC overall. The average response rates for child participants in NHANES were slightly higher (National Center for Health Statistics d). This study was deemed exempt by the Institutional Review Board under federal regulation 45 CFR Section 46.101(b).

Nutritional variables

PUFA intake and fish consumption were the outcomes of interest. Specifically, intake of LA, ALA, AA, EPA, and DHA, total *n*-3 (ALA, EPA, DHA), total *n*-6 PUFAs (LA, AA) and the n-6 : *n*-3 ratio were estimated. PUFA intake was extracted from the NHANES Total Nutrient files, which report summed nutrients from all foods reported on the 24-h dietary recall completed as part of the MEC using automated multi-pass methodology (National

Center for Health Statistics b). Extensive details about NHANES dietary assessment methods are publicly available (National Center for Health Statistics a) and have been validated (Conway *et al*. 2004). A proxy provided information for children younger than 6 years. The values for each PUFA were derived from the USDA's Food and Nutrient Database for Dietary Studies (FNDDS), which assigns a nutrient amount according to the type and amount of food reported eaten on a given day of the 24-h dietary recall (U.S. Department of Agriculture, Agriculture Research Service, Food Surveys Group 2010). Information on important dietary sources of PUFAs came from the NHANES Individual Foods Files, which list all foods reported eaten from the 24-h dietary recall (National Center for Health Statistics a).

For fish intake, we used the fish and shellfish food frequency questionnaire (FFQ), which is administered after the first 24-h dietary recall (National Center for Health Statistics b). This brief FFQ contains questions on specific fish and shellfish consumption in the previous 30 days (FFQ available on NHANES website).These data were used to estimate fish and shellfish intake, which we then categorised using a cut-point we defined as oily fish (fish with total n-3 content >0.2 g/oz), white fish (total n-3 content < = 0.2 g/oz), and shellfish (crab, lobster, shrimp, clams, mussels, scallops, oysters, crayfish). Similar to the 24-h recall, a proxy respondent answered for children younger than 6 years. For both nutrient and fish intake, we excluded children who were still breastfeeding since nutrient values from breast milk were not available (n = 52). We examined intake of PUFAs and fish by child age (12–24, 25–36, 37–48 and 49–60 months) and race/ethnicity (non-Hispanic white, non-Hispanic black and Mexican American). Both age and race/ethnicity are recorded as part of the demographic file of NHANES and both variables have no missing data (National Center for Health Statistics e). We excluded children of `Other' and `Other Hispanic' race/ethnicity (n = 389).

Statistical analysis

The mean, percentiles and standard error of PUFA intake by age and race/ethnicity were estimated using usual intake methodology from the National Cancer Institute (2010b). These methods include both food consumers and non-consumers (i.e. persons not reporting a certain food on the day of dietary recall) when estimating mean intake and use information from children who had at least one dietary recall to account for the intra-individual variation in intake. We used the MIXTRAN and DISTRIB Statistical Analysis Software (SAS; SAS Institute Inc., Cary, NC, USA) macros provided by NCI to estimate mean PUFA intake, percentiles and standard errors (National Cancer Institute 2010c). As nearly all children reported at least some amount of ALA, LA and AA intake (>95%), we ran amount-only models appropriate for foods consumed commonly for estimation of these nutrients (National Cancer Institute 2010b). Approximately 30% of children had no reported intake of EPA and DHA on their 24-h recalls. All usual intake models were adjusted for energy intake using the residual method (Willett *et al*. 1997) and used 48 balanced replicated repeated weights instead of the standard 1-day dietary recall weights, per NHANES guidance (National Center for Health Statistics f), to account for potential non-response bias and to make representative estimates.

We used *z*-score testing for the statistical comparison of PUFA intake by age and race/ethnicity using the means and standard errors generated by the usual intake methods. For age, we compared intake for children in the youngest age group to all other age groups, and for the race/ethnicity comparisons, we compared intake for non-Hispanic white children to children in all other race/ethnicity groups (race/ethnicity comparisons). Statistical significance was assessed at the $P < 0.05$ level.

Fish intake in the previous 30 days was assessed from the short FFQ by estimating the percentage of children who were reported to have eaten any fish and in each of the three categories of fish using PROC SURVEYFREQ in SAS (v. 9.3) and the standard 1-day dietary weight (SAS). Statistical significance in potential differences of reporting fish intake by age and race/ethnicity was determined using both Rao-Scott chi-square to test for general differences among age and race/ethnicity groups and logistic regression with any fish intake in the previous 30 days as the outcome (yes/no) and age group and race/ethnicity as independent variables in separate models. Logistic regression was used to confirm statistically significant differences of age and race/ethnicity with specific reference groups (12–24 months and non-Hispanic white, respectively) and not to generate odds ratios.

Last, in addition to fish intake, the food sources from the first day dietary recall that contributed most to intake of LA, ALA, AA, EPA and DHA were identified. This was carried out by first creating a weighted intake for a particular fatty acid by multiplying the amount of fatty acid of interest from each food reported on the dietary recall by the first-day dietary NHANES weight (National Center for Health Statistics c). We then calculated the frequency distribution of nine main food categories created by the USDA (USDA 2010) and weighed it using the newly created fatty acid weight to determine which food groups determined the most intake for a given fatty acid (National Center for Health Statistics c). Based on these results, we further refined the food groups to give more specificity to the types of foods that contributed the most to fatty acid intake in child diets.

Results

Of the 2496 children eligible for this study, 802 were 12–24 months, 744 were 25–36 months, 454 were 37–48 months, and 496 were 49–60 months of age (Table 1). Children were fairly evenly distributed by age group, and there were no statistically significant differences in the age distribution by race/ethnicity.

The food sources that were the most prominent contributors (accounted for >2% of intake) to intake of five PUFAs among young US children were identified (Table 2). Nuts, seeds and salty snacks; poultry; and pasta, rice and other grains were the largest contributors to LA intake, among numerous food groups. ALA intake was also accounted for by a range of foods; the two most predominant food groups were milk and yogurt (22.9%) and pasta, rice and other grains (11.1%).The majority of AA intake came from poultry and eggs. EPA and DHA intake can be attributed to a narrow range of food groups in this study. More than 64% of total EPA intake came from fish and shellfish, with poultry accounting for 15%. Fish and shellfish sources accounted for more than 46% of DHA intake; poultry and eggs made up the majority of the remainder of DHA intake (24.5% and 19.6%, respectively).

In adults, fish is a major driver of DHA and EPA intake (National Cancer Institute 2010a), so the proportion of children by age and race and ethnicity who were reported to have eaten any of the three categories of fish in the previous 30 days was calculated to evaluate what proportion of the population of children consume fish. Overall, 53.7% was reported as having eaten any fish (Table 3). Almost half of all children ate white fish, while only 14.0% ate oily fish and 28.0% ate shellfish. These proportions did not vary significantly by age.A greater proportion of non-Hispanic black children were reported to eat fish overall and white fish and shellfish than non-Hispanic white children. Oily fish consumption was relatively rare among Mexican American children, only 7.2%, with all other groups more than twice as likely to have eaten oily fish, but Mexican American children were more likely to have eaten shellfish than non-Hispanic white children.

Usual mean intakes of ALA, EPA, DHA, total *n*-3, LA, AA and total *n*-6 fatty acids are reported in Table 4. In general, intakes increased with age, upon adjustment for energy intake, although small differences among the youngest groups were often difficult to detect. Total *n*-3 intake did not change significantly with age, but total *n*-6 intake increased significantly (46% higher among children 49–60 months compared to 12–24 months). The youngest children also had the lowest *n*-6 : *n*-3 ratio. No significant differences in DHA intake were noted with age, but the oldest children had EPA and AA intakes significantly higher than the youngest.

To evaluate potential differences in PUFA intake by race and ethnicity, all age groups were combined to estimate mean intakes for non-Hispanic white, non-Hispanic black and Mexican American groups (Table 4). Total *n*-3 and *n*-6 intake did not vary by race. However, in terms of the individual PUFAs, Mexican American children had significantly higher intake of DHA and AA compared to non-Hispanic white children.

Discussion

Based on a nationally representative sample of US children, this study found that among children ages 12–60 months, there were significant increases with age (49–60 months vs. 12–24 months) in intake of several key PUFAs but not others, even after adjustment for energy intake. Predominant sources of DHA and EPA in the diets of children ages 12–60 months include fish and shellfish and poultry, but only slightly more than half of children were reported to eat any fish in the previous month. Differences by race and ethnicity were limited to major differences in DHA and AA only, with Mexican American children having much higher intakes than non-Hispanic white children. Differences in fish consumption may explain some of these differences in PUFA intake if shellfish intake among Mexican American children is high enough to outweigh their low intake of fatty fish.

No previous US studies have used a representative sample of young children to examine variation in PUFA intake by age group and race/ethnicity early in life. Although it was not always possible to detect small differences between, for instance, 12–24 and 25–36 months, significant increases in intake of particularly *n*-6 PUFAs were observed between 12–24 and 49–60 months. *n*-6 fatty acid intakes appeared to increase with age. Although no major differences in DHA intake were observed within the 12–60 months age range, these intake levels almost certainly represent a significant reduction from intakes during infancy. This study was unable to formally compare infant (i.e. younger than 12 months) PUFA intakes to older children because NHANES does not collect data on the nutrient content of breast milk. However, using assumptions about breast milk and infant formula concentrations, one can estimate that an infant fed a typical infant formula would consume approximately 70 mg day^{-1} DHA and a breastfed infant 42 mg day^{-1} DHA (583 mL 0.020% DHA milk or 0.012% DHA formula consumed) (Paul *et al*. 1988; Keim *et al*. 2011; U.S. Department of Agriculture 2011).The 20 mg day^{-1} average intake reported in this study reflects a 48–71% reduction from these infant intakes. Whether this has implications for the health of young children is unclear.

Mean intakes of LA and ALA in this study were at or above the US Institute of Medicine (IOM) Dietary Reference Intakes (LA: 7.0 g day^{-1} for 1–3 years of age, 10.0 g day^{-1} for 4–8 years of age;ALA: 0.7 g $day^{-1}$for 1–3 years of age, 0.9 g day^{-1} for 4–8 years of age). To provide context to these results, this study informally compared them to studies in other countries (Table 5), although methods for estimating intakes and the age groups varied somewhat across studies. One key difference included the higher mean intake of total *n*-6 fatty acids among US children (8.6 for ages 12–60 months) compared to all other listed countries. US children also demonstrated lower DHA and EPA intakes compared to all, except possibly Australian children. Relative to other countries' recommendations, US children consumed well below the Netherlands recommendations of 150–200 mg day^{-1} EPA + DHA, and all age groups were also below the relatively modest Australia and New Zealand recommendations for 40 mg day^{-1} DHA + EPA + docosapentaenoic acid at 1–3 years and 55 mg day^{-1} at 4–8 years of age (National Health and Medical Research Council, Department of Health and Ageing, Australian Government and Ministry of Health, New Zealand 2005).

The proportion of children who were reported to have consumed fish varied by the type of fish. White fish was more commonly eaten than shellfish, and oily fish was consumed by the fewest children. White fish tends to be lower in EPA and DHA than oily fish, and many seafood products popular with children (e.g. fish sticks) are made with white fish (Institute of Medicine, Committee on Nutrient Relationships in Seafood: Selections to Balance Benefits and Risks, & Food and Nutrition Board 2007; U.S. Department of Agriculture 2011). The IOM has published a reasonable intake level of two 3-oz servings per week for children, but this is difficult to compare with this study's estimates because this study was only able to estimate the proportions consuming any fish (Institute of Medicine, Committee on Nutrient Relationships in Seafood: Selections to Balance Benefits and Risks, & Food and Nutrition Board 2007). However, 47% of children who consumed no fish certainly are not meeting this goal, and it appears that children are not increasingly likely to become fish consumers with age. The large UK ALSPAC birth cohort study also reported that oily fish consumption was lower than white fish consumption among young children, although intake of both types of fish was more common in the ALSPAC children than among US children: 11% of ALSPAC children 1.5–4.5 years of age consumed oily fish daily and 56.2% consumed white or shellfish daily, per a 3-day food record (Cowin & Emmett 2007). The Nestlé Feeding Infants and Toddlers Study found via dietary recall that the proportion of US children ages 12–23 months who consume fish or shellfish daily ranged 2.8–7.2%, but this estimate was imprecise due to small sample size and is not directly comparable to this study's estimate (Siega-Riz *et al*. 2010). Total fish consumption also appears to be lower among US children compared to Belgian children 2.5–6.5 years of age (31% reported eating fish within a 3-day period) (Sioen *et al*. 2007). One reason for the low prevalence of fish intake among US children may be confusion and uncertainty on the part of parents about whether and what types of fish are safe and healthy for children to eat, in the context of the complex public health messages being communicated in the United States on this topic (Vardeman & Aldoory 2008).

To the authors' knowledge, this is the first study of a representative sample of US children to evaluate racial and ethnic differences in PUFA and fish intake. Non-Hispanic black children were more likely to consume fish (white fish and shellfish) than non-Hispanic white children, but this did not translate into a difference in EPA and DHA intake. These findings are in line with the previous studies of US adults including Coronary Artery Risk Development in Young Adults (CARDIA) and the Multiethnic Cohort Study that show greater intake of fish among Black adults (Sharma *et al*. 2003, 2004; Iribarren *et al*. 2004). While few Mexican American children were reported to eat oily fish and only 47% ate any fish, shellfish consumption was more common in this group compared to non-Hispanic white children. This may explain the higher DHA intake in this group.

Although many young children do not consume fish at all, fish and shellfish remain the largest contributor food groups to overall EPA and DHA intake in young children. Compared to adults, however, children obtain a greater proportion of EPA and DHA from foods like poultry, eggs and cereals (National Cancer Institute 2010a). According to the data from NHANES 2005–2006, fish and shellfish contribute 71.3% of EPA + DHA intake to the adult diet, while poultry contributes 13.8% and eggs 5.8% (National Cancer Institute 2010a). Cereals; eggs; waffles, pancakes and doughnuts; and pasta, rice and grain dishes contribute less than 1% each of the total EPA + DHA to the adult diet but a greater proportion to young children's diets (National Cancer Institute 2010a). Sources of ALA in children's diets are even more distinct from sources in the adult diet. ALA intake is driven largely by consumption of milk and yogurt; pasta, rice and other grains; and fruits and vegetables (a substantial proportion as fried potatoes) in children's diets, while for adults, sources are more varied but are led by salad dressing, chicken and grain-based desserts (National Cancer Institute 2010a). US adults and children derive LA from similar sources, with the exception of salad dressings for adults and more prominence of nuts, seeds and salty snacks, including potato chips, for children. This food group analysis indicates that the existing data on food group contributors of PUFAs to adult diets do not apply to young children and suggests opportunities for dietary changes that could improve the balance of PUFAs in children's diets. For instance, reduced consumption of certain foods and increased intake of other foods with a more favourable PUFA profile may lower n-6 : n-3 ratios and increase DHA and EPA intakes (e.g. swapping fried chicken nuggets for roast chicken breast if children enjoy chicken but not fish). While further research is needed to clarify the health impact of dietary changes such as these in terms of the role of PUFAs specifically, alterations like these often have the additional benefit of reducing sodium and saturated fat intake.

Our study was limited by the methods used to assess dietary intake in NHANES. This study was unable to estimate the amounts of fish consumed, and this limited the ability to assess differences across groups beyond the simple prevalence of eating any fish in the 30 days prior to interview. However, the FFQ was preferable to reliance on the dietary recall because fish is a relatively rarely consumed food. Overall, given the challenges of dietary assessment in this very young population and the paucity of validated instruments that are age-appropriate, our methods reflect the current state of research practice. Finally, the comparisons with studies from other countries are limited by the differences in methodologies used and survey sampling procedures. Nevertheless, the present study has strength in its large sample size and representativeness of the US population and the use of usual intake methods to estimate PUFA intake.

This study provides detailed information on dietary intake of key PUFAs among young US children, and to the authors' knowledge, this is the first detailed examination of PUFA intake among young children in the United States. This study concludes that intake of certain important PUFAs varies by age, with the youngest children consuming the lowest amounts. The study also found that some of the same racial and ethnic differences in fish consumption that have been documented in some adult studies are also present in young children. These results suggest that there is a room for improvement in PUFA intake among young children in the United States. Increasing fish consumption and reducing consumption of processed foods like salty snacks (chips) and fried poultry are two steps that could be taken to improve the balance of PUFAs in the diets of US children. Connections between dietary intakes of PUFAs and health outcomes in this young age group deserve further study, particularly because much of the research in this area has focused on the efficacy of high-dose PUFA supplements rather than the effect of lower amounts of PUFAs typically acquired through the diet. Whether the differences observed among the age and racial and ethnic groups in the present study are meaningful for paediatric health outcomes is an important question to be answered. The present study may serve as a foundation for that future investigation.

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Key messages

- Predominant sources of DHA and EPA in the diets of young children included fish and shellfish and poultry, but more than half of children ate no fish in the previous month.
- EPA and *n*-6 PUFA intakes and the *n*-6 : *n*-3 ratio were higher for children 49–60 months compared to children 12–24 months of age; DHA intake remained low across age groups.
- Mexican American children were more likely to consume shellfish, less likely to consume oily fish and had higher DHA and AA intake than non-Hispanic white children; non-Hispanic black children were more likely to consume fish than non-Hispanic white children.

Table 1

Proportions of children 12–60 months by age and selected race/ethnicity groups*: National health And Nutrition Examination Survey 2003–2008

	Total	Non-Hispanic white	Non-Hispanic black	Mexican American
	***n* (% [SE])**	***n* (% [SE])**	***n* (% [SE])**	***n* (% [SE])**
Age group (months)	*n* = 2496	*n* = 883	*n* = 724	*n* = 889
12–24	*n* = 802 (23.0 [1.0])	283 (66.6 [2.9])	231 (16.0 [2.0])	288 (17.4 [1.9])
25–36	*n* = 744 (22.4 [0.9])	270 (65.6 [3.5])	192 (15.3 [2.3])	282 (19.1 [2.3])
37–48	*n* = 454 (18.2 [1.3])	148 (60.5 [4.2])	164 (21.7 [2.8])	142 (17.8 [3.1])
49–60	*n* = 496 (21.3 [1.3])	182 (67.9 [3.3])	137 (15.0 [2.0])	177 (17.2 [2.3])

* There were no statistically significant differences in the age distribution by race/ethnicity.

Table 2

Greatest contributing food groups (percent and standard error) to dietary intake of certain polyunsaturated fatty acids among US children ages 12–60 months, National Health and Nutrition Examination Survey, 2003–2008

	LA*	ALA*	AA*	EPA*	DHA*
	% (SE)	% (SE)	% (SE)	% (SE)	% (SE)
Fish and shellfish	–	–	2.8 (0.4)	64.2 (2.8)	46.3 (3.0)
Poultry and poultry dishes	12.5 (0.7)	7.6 (0.5)	32.5 (1.5)	14.6 (1.3)	24.5 (2.0)
Cereals	–	–	–	5.6 (0.6)	–
Eggs and egg dishes	3.2 (0.3)	2.5 (0.2)	27.5 (1.6)	4.9 (0.5)	19.6 (1.4)
Waffles, pancakes and doughnuts	3.2 (0.3)	2.2 (0.2)	–	3.6 (0.6)	–
Pasta, rice and other grain dishes	11.3 (0.5)	11.1 (0.5)	8.1 (0.5)	–	2.2 (0.4)
Milk and yogurt†	6.1 (0.3)	22.9 (0.7)	–	–	–
Fruits and vegetables	3.8 (0.2)	6.2 (0.3)	–	–	–
Nuts, seeds and salty snacks‡	20.5 (0.9)	7.5 (0.5)	–	–	–
Yeast breads and quick breads	7.3 (0.5)	6.6 (0.5)	–	–	–
Condiments	4.4 (0.8)	6.0 (1.1)	–	–	–
Grain-based desserts	5.0 (0.3)	3.8 (0.3)	–	–	–
Other meat dishes, including assorted lunchmeats	4.0 (0.3)	3.7 (0.2)	9.6 (1.0)	–	–
Cheeses and cheese dishes	–	3.6 (0.2)	2.3 (0.2)	–	–
Table and cooking fats	2.0 (0.3)	2.5 (0.4)	–	–	–
Beef and beef dishes	–	2.1 (0.2)	7.8 (0.6)	–	–
Pork and pork dishes	–	–	3.5 (0.4)	–	–

AA, arachidonic acid; ALA, alpha-linolenic acid; DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid; LA, linoleic acid.

*Food groups contributing less than 2.0% to intake of each fatty acid are not shown.

†Includes infant formula.

‡Peanut butter was included with beans and meatless dishes which did not contribute significantly to polyunsaturated fatty acid intake and so is not shown.

Table 3

Frequency and type of fish consumed by age and race and ethnicity among US children ages 12–60 months, National Health and Nutrition Examination Survey, 2003–2008

	Any fish	White fish*	Oily fish	Shellfish
	Percentage eating fish or shellfish in past 30 days (SE)			
All ages combined (months)	53.7 (1.8)	49.4 (1.8)	14.0 (1.5)	28.0 (1.8)
12–24	52.4 (2.5)	48.1 (2.2)	13.8 (2.4)	24.0 (2.4)
25–36	55.0 (2.6)	51.4 (2.7)	13.2 (2.2)	25.7 (1.8)
37–48	56.2 (3.4)	52.4 (3.3)	11.4 (2.3)	31.1 (3.4)
49–60	51.7 (3.4)	46.1 (3.3)	17.2 (2.9)	32.0 (4.0)
Non-Hispanic white	53.0 (2.7)	48.6 (2.7)	14.7 (2.3)	23.5 (2.6)
Non-Hispanic black	64.0 (2.1)†	59.3 (2.3)‡	18.4 (2.2)	39.3 (2.4)†
Mexican American	46.9 (2.4)	43.0 (2.3)	7.2 (1.2)‡	33.8 (2.2)‡

*Includes unspecified types of fish and `other' types of fish.

†Significantly different from non-Hispanic white at the $P < 0.001$ level.

‡Significantly different from non-Hispanic white at the $P < 0.01$ level.

Table 4

Estimated daily dietary intake of individual polyunsaturated fatty acids (PUFAs) by age and race and ethnicity among US children ages 12–60 months,National Health and Nutrition Examination Survey, 2003–2008

Polyunsaturated fatty acid	All children	12–24 months	25–36 months	37–48 months	49–60 months	Non-Hispanic white	Non-Hispanic black	Mexican American
	(*n* = 2496)	(*n* = 802)	(*n* = 858)	(*n* = 454)	(*n* = 496)	(*n* = 883)	(*n* = 724)	(*n* = 889)
	Mean (SE) [IQR]	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)
Alpha-linolenic acid 18:3 (ALA) (g)	0.86 (0.032) [0.66, 1.02]	0.82 (0.033)	0.86 (0.032)	0.87 (0.034)	0.90 (0.039)	0.85 (0.034)	0.87 (0.031)	0.88 (0.033)
Eicosapentaenoic acid 20:5 (EPA) (mg)	6.03 (0.67) [3.88, 7.46]	5.00 (0.56)	5.72 (0.63)	6.41 (0.70)	7.18 (0.82)*	5.64 (0.66)	6.32 (0.68)	6.90 (0.80)
Docosahexaenoic acid 22:6 (DHA) (mg)	20.47 (3.09) [10.83, 26.19]	19.78 (3.00)	20.50 (3.03)	20.80 (3.20)	21.00 (3.59)	15.95 (2.77)	23.33 (3.38)	32.78 (4.67)*
Total n-3 fatty acids (18:3, 20:5, 22:6) (g)	0.89 (0.034) [0.68, 1.05]	0.84 (0.034)	0.89 (0.035)	0.90 (0.038)	0.93 (0.043)	0.88 (0.036)	0.91 (0.032)	0.92 (0.035)
Linoleic acid 18:2 (LA) (g)	8.47 (0.280) [6.46, 10.07]	7.03 (0.290)	7.99 (0.283)†	9.01 (0.315)†	10.16 (0.402)†	8.49 (0.300)	8.44 (0.280)	8.46 (0.284)
Arachidonic acid 20:4 (AA) (mg)	60.16 (2.54) [24.70, 83.6]	56.13 (3.24)	56.87 (2.71)	61.64 (3.96)	67.63 (4.38)*	53.22 (2.92)	61.30 (3.98)	79.36 (5.41)†
Total *n*-6 fatty acids (18:2, 22:5) (g)	8.55 (0.281) [6.52, 10.10]	6.97 (0.292)	8.19 (0.301)*	9.10 (0.330)*	10.16 (0.399)*	8.54 (0.295)	8.67 (0.307)	8.46 (0.286)
n-6 : *n*-3 ratio	10.4 (0.3) [8.28, 12.07]	8.9 (0.2)	10.0 (0.3)*	10.9 (0.3)*	12.0 (0.4)*	10.6 (0.3)	10.3 (0.3)	9.9 (0.3)

All PUFAs adjusted for energy intake and reflect weighted estimates.

*Significantly different from 12–24 months reference group at the $P < 0.05$ level.

†Significantly different from 12–24 months reference group at the $P < 0.01$ level.

Table 5

International comparison of estimated mean daily dietary intake of polyunsaturated fatty acids among young children

Country	Age group (years)	LA (g)	ALA (g)	AA (mg)	EPA (mg)	DHA (mg)	Total *n*-3 (g)	Total *n*-6 (g)
Australia*	2–3	6.10	0.68	16	10	24	0.72	6.20
Australia*	4–7	7.50	0.81	22	19	47	0.88	7.60
Belgium†	2.5–3	6.71	0.81	17	22	43	–	–
Belgium†	4–6.5	7.12	0.86	18	26	49	–	–
Canada‡	1.5–2	5.80	1.16	133	29	41	–	–
Canada‡	2.1–3	9.04	2.02	260	57	95	–	–
Canada‡	3.1–5	9.39	1.72	226	60	96	–	–
Canada§	4–7	7.40	0.71	57	17	37	0.75	7.40
Canada¶	4–8	7.58	1.16	–	38	54	1.30	7.74
China**	1–3	2.08	2.78	55	–	34	0.35	2.14
China**	4–5	2.27	3.35	50	–	23	0.38	2.32
U.S. (present study)	1–4	8.47	0.86	60	6	20	0.89	8.55

AA, arachidonic acid; ALA, alpha-linolenic acid; DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid; LA, linoleic acid.

*Meyer *et al*. (2003);

†Sioen *et al*. (2007);

‡Innis *et al*. (2004);

§Lien & Clandinin (2009);

¶Madden *et al*. (2009);

**Barbarich *et al*. (2006).